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ORIGINAL PAPER

Trends and prospects for local knowledge in ecological and conservation research and monitoring

Ryan K. Brook · Stéphane M. McLachlan

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Abstract Local ecological knowledge (LEK) of those who earn their livelihoods from natural environments has long been recognized as providing far-reaching insights into ecological processes. It is being increasingly used by ecologists to address diverse questions that often focus on applied conservation issues and may incorporate local knowledge with biological data from more conventional research and monitoring. We characterize how LEK has been used in the ecological and conservation literature over the last 25 years by broadly examining 360 journals and by evaluating 12 prominent ecological and conservation journals in greater detail. Over this period, the use of LEK has increased considerably, although only 0.01% of papers in the broad and 0.42% of those in the more detailed evaluation incorporated LEK. Despite this increase, LEK-based publications remain nearly absent from the more established theoretical literature and are largely restricted to more recent and arguably less prestigious applied and interdisciplinary journals. Most LEK studies used interviews, but generally failed to actively include community members in the research process. Changes to the research and publishing process that include local people and address these shortcomings and the broader issues of power and influence in the sciences are critical to the successful utilization of LEK. These changes are necessary for the appropriate depiction of these knowledge systems and to ensure that local knowledge holders will continue participating in ecological research aimed at conservation.

Keywords Indigenous people · Farmer · Biodiversity conservation · Traditional ecological knowledge · Power · Collaboration · Communication

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Abbreviation
LEK Local Ecological Knowledge

Introduction

The use of experience-based knowledge by scientists represents an important emerging area of ecological research (Sillitoe 1998; Huntington 2000; Balram et al. 2004; Brook and McLachlan 2005; Halme and Bodmer 2007). Variously referred to as Indigenous Knowledge, Traditional Ecological Knowledge, or, more generally, Local Ecological Knowledge (LEK), these rich insights are held by lay people working in and making their livelihoods from natural environments.

As large-scale environmental change becomes apparent, it is increasingly recognized that conventional ecological research cannot always be conducted quickly enough and over large enough areas to understand associated complex, long-term changes, and that LEK can provide valuable insights for researchers, managers, and policymakers (Stave et al. 2007; Brook 2007). While researchers seek new approaches to understanding and managing complex environmental problems, society increasingly questions the outcomes of conventional ecological research, especially when the science conflicts with existing local knowledge, concerns, and values (Tesh 2000). The documentation of local knowledge can provide important avenues for discussion and building dialogue between scientists and the communities in which they work (Turner et al. 2000), and help ground studies in the realities of non-experts throughout the research process.

There is no universally accepted definition of LEK, nor does it appear that one is forthcoming or even desirable (Brook et al. 2006). This is perhaps not surprising given the complexities of these knowledge systems, the diversity of environments and cultures that they reflect, and the myriad ways that they are viewed, documented, and used (e.g. Berkes 1999; McGregor 2000). Many different approaches and terms are used to describe these diverse knowledge systems, including Traditional Ecological Knowledge (Berkes et al. 2000), Indigenous Knowledge (Berkes 1999), Rural Peoples' Knowledge (Kothari 2002), Farmer Knowledge (Mauro and McLachlan 2008), or Folk Knowledge (Berkes 1999). For the purposes of this paper we will use the most inclusive term, LEK.

Most descriptions of LEK emphasize the importance of practical skills and wisdom developed through experience in and earning livelihoods from the environment (Berkes 1999). It is largely orally transmitted, is cumulative, is typically local in scale, and builds on the experiences of past and present generations through mentoring, storytelling, and cooperative work (McGregor 2000). Researchers use many different approaches when characterizing experience-based knowledge and often interact with knowledgeable individuals and Elders residing in resource-dependent communities (Ferguson et al. 1998; Brook and McLachlan 2006). These knowledge systems continually evolve, responding to changing environmental and societal conditions (Davis and Wagner 2003). Indeed, LEK can readily incorporate technology and scientific discoveries where appropriate, such that the distinctions between LEK and conventional science often become blurred (Agrawal 1995). As such, it provides a rich, spatially and temporally explicit, and long-term body of knowledge.

The application of local knowledge has many obvious advantages in understanding and responding to ecological problems (Bart 2006), yet its use often remains controversial. It has been rejected by some scientists as 'anecdotal', 'imprecise', 'unsubstantiated', or 'inaccurate' (Johannes 1993; Hobson 1993; Gilchrist et al. 2005). Some even question

whether it has any meaningful place in ecological research, labelling it as pseudo-science or even anti-science (e.g. United States National Committee for the International Union of the History and Philosophy of Science 2001; Howard and Widdowson 1996; Widdowson and Howard 2002). In turn, these criticisms receive measured responses from those whom see it as a viable and valuable field of inquiry (e.g. Berkes and Henley 1997; Brook and McLachlan 2005). Perhaps the most challenging aspect of LEK for individuals trained in the ecological sciences to absorb and respect is the cultural and political context for and spiritual aspects of local knowledge, the latter including creation myths and cosmologies used to explain the origin of earth and its people and the codes of ritual and behaviour that govern relationships with their environments (Assembly of First Nations, National Aboriginal Forestry Association 1995). This knowledge may be acquired through dreams, prayers, ceremonies, self knowledge, and learning-by-doing, and is important for Indigenous Peoples around the world as well as for farmers and commercial fishers (McGregor 2000; Ver Beek 2000; Simpson 2001a; Mauro and McLachlan 2008). These aspects may initially be viewed as irrelevant or inconvenient since university-based science education often stresses an objective approach that is dissociated from this cultural background. Indigenist researchers have argued that Aboriginal Knowledge systems can be compromised and sometimes even appropriated by conventional LEK research (Simpson 2001b). That these knowledge holders rarely have influence, much less control, over how the knowledge is portrayed and used further aggravates this concern (Brook and McLachlan 2005).

It is now widely accepted (sensu Kuhn 1962) that science undergoes periodic revolutions, or paradigm shifts whereby a field is suddenly changed, and the incorporation of LEK into contemporary ecological and conservation research arguably represents such a shift in thinking. As LEK has become more widely recognized, some suggest that perhaps the number of peer-reviewed publications that utilize LEK is increasing (e.g. Duerden and Kuhn 1998; McGregor 2000). These changes and the body of ecological literature that incorporates LEK have yet to be characterized and evaluated. Our goal here is to assess how and to what degree LEK is used in the peer-reviewed ecological literature. While there are options for publishing LEK research in journals that reflect other disciplines including Anthropology and Native Studies, we focus solely on the ecological and conservation literature, as these journals are the primary and most effective forum for most ecologists to publish their work.

Methods

Broad literature analysis

In order to assess patterns in the publication of experience-based local knowledge within the ecological literature, we used a bibliometric analysis, which involves a systematic examination of the number and type of publications within a discipline which are interpreted based on a coding scheme developed a priori (Prichard 1969). In total, all of the 360 environmental, conservation, and ecology journals representing 7.5 million papers within the Biological Abstracts digital database were searched for each year from 1980 to 2004 (Thomson Corporation 2006). Searches of the title and abstract fields of the Biological Abstracts were based on key terms for LEK and other key words that could identify papers that employed local knowledge (ethnobotany, ethnoecology, interview, participant observation, and mail survey) to avoid missing any potential papers that incorporated LEK. Boolean operators were used for terms that included more than one word and searches

included the title and abstract when it was available. The searches were run individually for each of the 25 years examined using the same search approach to ensure that the results were directly comparable among years and all papers identified in the search as potentially using LEK were subsequently examined in detail to confirm the use of local knowledge.

Detailed literature analysis

While the key term search provided insights into the general trend in the number of publications that utilize LEK across the ecological literature as a whole, we were also interested in examining a subset of these journals in more detail to (a) provide insights into the methods that were used and how the researchers interacted with the communities they working in; and (b) validate the observed temporal trend observed in the broader analysis. This finer scale analysis examined 12 randomly selected ecological journals in much greater detail over the same 25-year period as the broader analysis. We then used these results to critically examine the ways in which LEK is used within the ecological and conservation literature and to provide suggestions for dealing with some of the challenges that confront ecologists interested in incorporating LEK.

The selected journals within the ecological literature were those that largely catered to a North American readership. We identified the Journal Impact Factor score for each journal, which is calculated annually as the average number of times that articles published in a specific journal in the two previous years were cited in a particular year (Sutherland 1999; Popescu 2003) and which, more generally, is used by many to assess the legitimacy and impact of any given journal. The journals were stratified by impact factor and categorized within each of three broad classes (theoretical, interdisciplinary, and applied) according to their mission statements. Four journals were randomly selected from each class: the first class theoretical (i.e. Canadian Journal of Botany, Canadian Journal of Zoology, Ecological Monographs, and Ecology), the second class interdisciplinary (i.e. Agriculture, Ecosystems and Environment [previously Agro-Ecosystems], Arctic, Ecology and Society [previously Conservation Ecology], and Trends in Ecology and Evolution), and the third class applied (i.e. Canadian Journal of Fisheries and Aquatic Sciences, Canadian Journal of Forest Research, Conservation Biology, and Ecological Applications). Eight of these journals had been published before 1980 and four had been subsequently created, the latter group including Trends in Ecology and Evolution (1986–2004), Conservation Biology (1987–2004), Ecological Applications (1991–2004), and Conservation Ecology/Ecology and Society (1997–2004). In total, 40,900 articles were assessed in detail from these 12 journals and the 'methods', 'results', 'discussion', and 'acknowledgement' subsections were reviewed for their explicit use of local knowledge. By going through each article individually, we could identify studies using LEK that might be not captured in the broader key word search. This detailed analysis allowed us to document the methods used to study LEK in each paper, as well as the subject of each study, the region it was conducted, and the types of people that were researched.

Results

The number of published conservation and ecology articles using LEK has increased over the last 25 years (Fig. 1). In total, 421 papers were found in the broader analysis, representing 0.01% of all papers published over that period. We similarly identified 172 articles using LEK in the 12 ecological journals we examined in detail, representing 0.42% of papers from 1980 to 2004. The degree to which LEK is used varies greatly among the

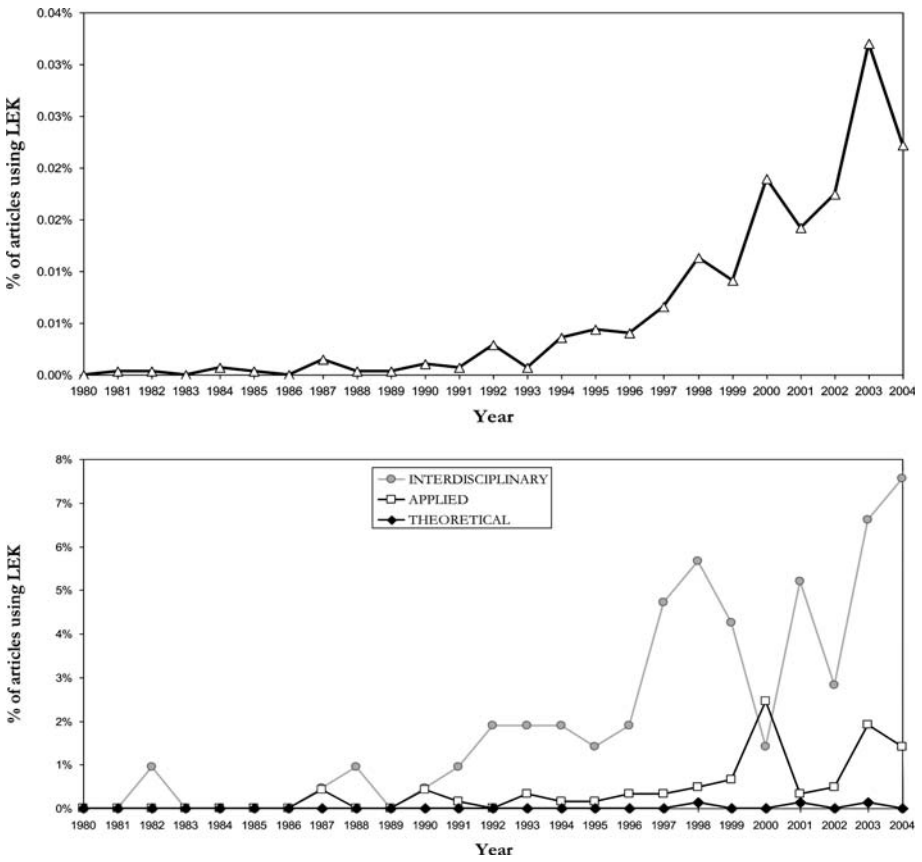

Fig. 1 Changes in publications using TEK over the last 25 years. (**a**) Percentage of articles in the Biological Abstracts database per year using experience-based local knowledge from 1980 to 2004; (**b**) and percentage of the 40,900 articles in the four theoretical, four applied, and four interdisciplinary journals examined in detail that used LEK

12 journals examined in detail, the highest being (in descending order of use): Ecology and Society (8.6%), Arctic (7.7%), Conservation Biology (5.1%), Ecological Applications (1.2%), and Agriculture, Ecosystems and Environment (0.9%) (Table 1). In contrast, use of LEK is rare to non-existent in the other seven journals. In each of the journals that incorporate LEK studies, there has been an overall increase in the proportion of studies using LEK, especially in Ecology and Society and in Conservation Biology.

For the LEK publications examined in detail, more than one third lack a detailed methodology, so for these the participants often cannot be characterized or even identified (occupation, gender, and age) (Fig. 2). Only 11% of the empirical papers explicitly recognize or discuss a spiritual component to the local knowledge in the study since they generally focus on the more practical aspects of LEK. LEK studies involve a wide range of participants and their livelihoods, but most rely on farmers and hunters (Fig. 2). While many studies (42%) acknowledge the communities and individuals that shared their knowledge and 6% include the participants as co-authors, more than half of all studies (52%) fail to explicitly recognize the contribution of study participants in any way (Fig. 3). Moreover, only 24% of studies indicate that any feedback was obtained from the community. Most of

Table 1 Use of local knowledge in twelve ecological journals in five year blocks covering a 25 year span from 1980 to 2004

Journal	Period				
	1980–1984 (%)	1985–1989 (%)	1990–1994 (%)	1995–1999 (%)	2000–2004 (%)
Theoretical					
Canadian Journal of Zoology	0.0	0.0	0.0	0.0	0.1
Canadian Journal of Botany	0.0	0.0	0.0	0.1	0.1
Ecological Monographs	0.0	0.0	0.0	0.0	0.0
Ecology	0.0	0.0	0.0	0.0	0.0
Mean	0.00	0.00	0.00	0.03	0.05
Interdisciplinary					
Ag., Ecosystems and Env.[a]	0.20	0.0	0.4	1.7	2.3
Trends In Ecology and Evolution	–	0.0	0.0	0.2	0.2
Ecology and Society[b]	–	–	–	5.0	10.1
Arctic	0.0	3.6	9.1	14.0	8.6
Mean	0.17	0.20	0.94	2.30	2.87
Applied					
Can J of Fish and Aquatic Sci.	0.0	0.0	0.0	0.0	0.3
Can J Forest Research	0.0	0.0	0.0	0.0	0.0
Conservation Biology	–	1.8	3.2	3.7	10.5
Ecological Applications	–	–	0.0	0.7	2.4
Mean	0.00	0.09	0.21	0.39	1.33

[a] Formerly Agro-Ecosystems (1974–1983)

[b] Formerly Conservation Ecology (1997–2000)

the data in the papers we examined communicated in the voice of the researchers, and only 12% of the empirical studies include direct quotes from study participants. Of the latter, a median number of nine quotes is used. Only one study explicitly indicates that participants were compensated for their contribution. The biomes studied were diverse, including 36% arctic, 34% temperate, 16% tropical, and 14% arid (Fig. 3). The continents studied in the LEK publications are predictably focused on North America (55%) given that we explicitly selected journals with that area of focus, but also include Asia (17%), Africa (15%), Europe (7%), South America (4%), and Australia (2%) (Fig. 3).

Discussion

Embracing local knowledge

There is an increasing number of ecologists and conservation biologists actively employing LEK and working collaboratively with communities, which helps accumulate a critical mass of evidence for and support of the value of local knowledge (Kimmerer 2002; Berkes 2004; Brook 2007). Its importance is becoming more widely recognized, and needs that have been identified include the major gaps in data that exist for remote or inaccessible environments such as the Arctic or marine systems, high priority issues such as climate change and species extinction, and where LEK use is required by law. In northern Canada for example, scientists are now required to actively involve community members in their research projects and the use of LEK is strongly encouraged and in some cases mandatory (Usher 2000). Yet <0.5% of the papers that we examined explicitly incorporated LEK.

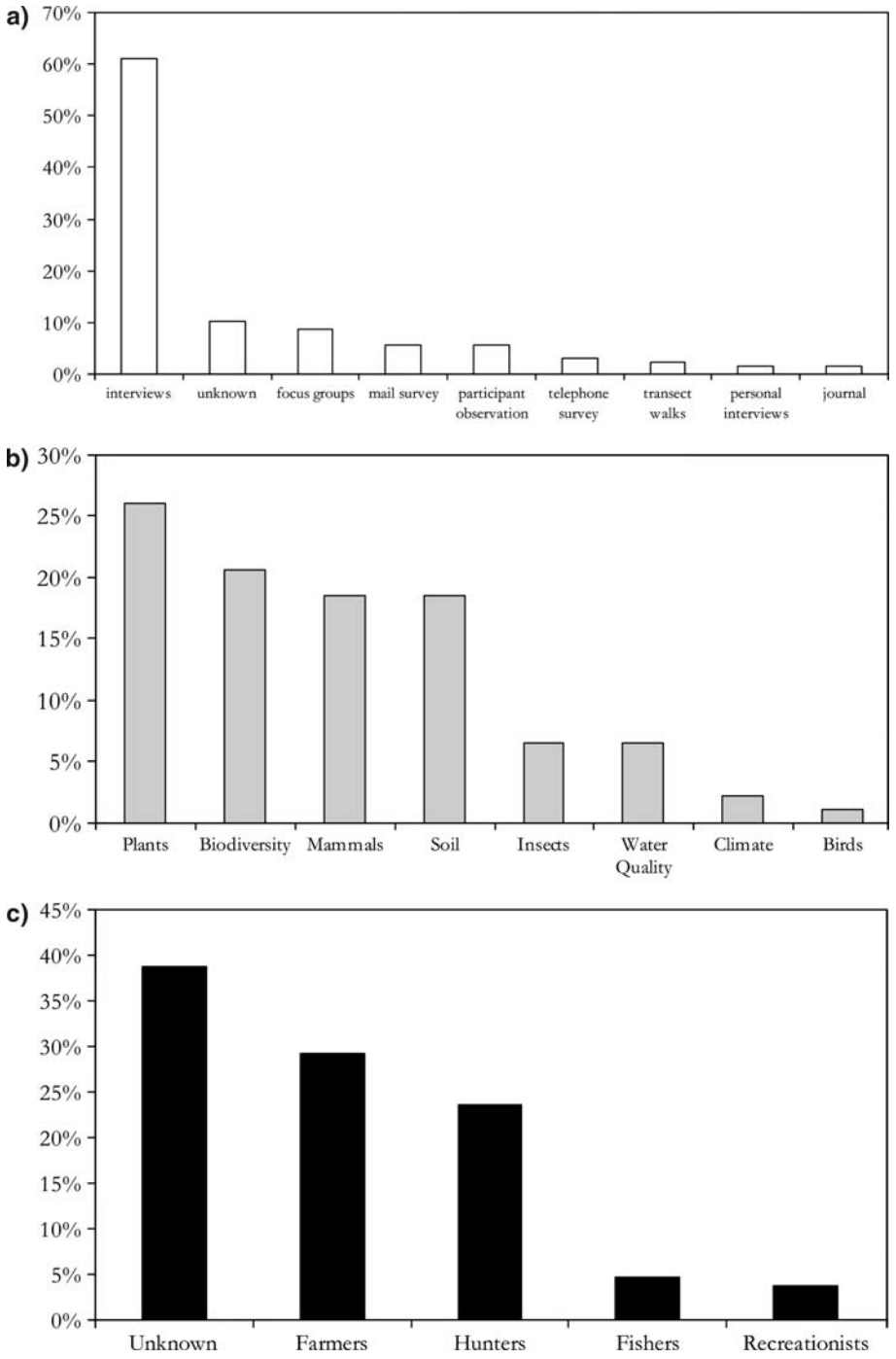

Fig. 2 Use of different approaches to documenting Local Ecological Knowledge (**a**); focus of each study (**b**); and the occupation of study participants (**c**)

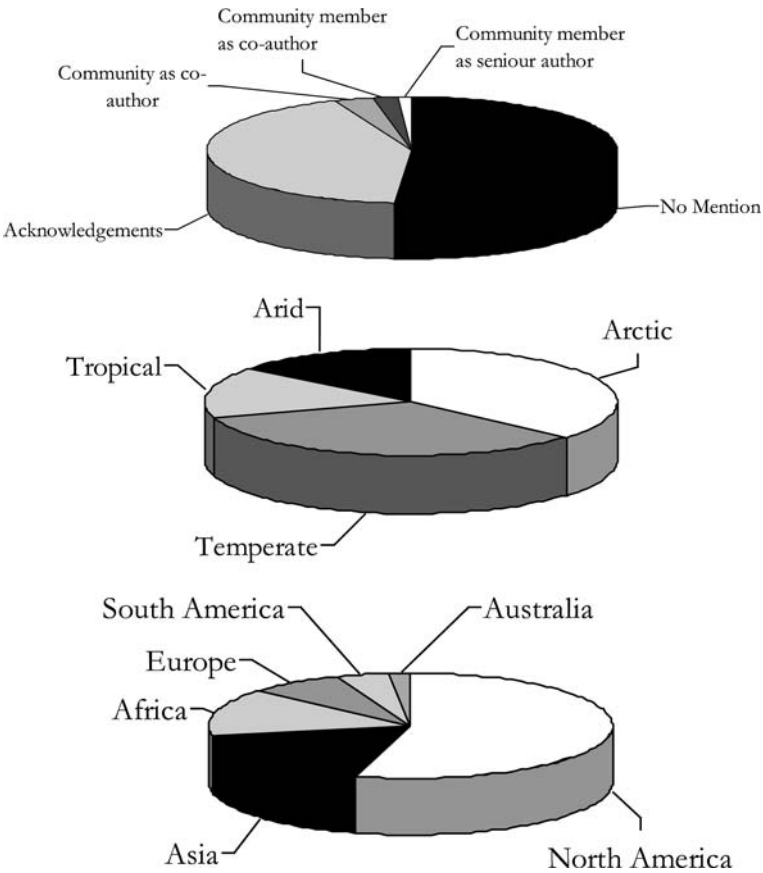

Fig. 3 Ways that LEK is acknowledged in the ecological literature (**a**). Spatial distribution of studies incorporating local ecological knowledge by biome (**b**) and continent (**c**)

Some of the key challenges for ecologists using LEK are pragmatic, and reflect a different research culture than many have been exposed to in the past, particularly adopting social research techniques to collect ecological data (Huntington 2000). Few ecologists are formally trained in the social sciences, and interdisciplinary studies that combine or integrate both ecological and social research are rare outcomes of interdisciplinary team-based research (Brook et al. 2006). These skills are still not reflected in most university ecology programs (Berkes 2005) and will likely only be promoted when the need and benefits of incorporating local knowledge become readily apparent and funding is made available. More training opportunities are required in university-level conservation ecology programs in order to nurture the familiarity, openness, and sensitivity needed to address these issues and ensure the next generation of scientists is capable of effectively using local knowledge in research. This training should include opportunities to engage aboriginal and rural communities within a collaborative framework and mentoring researchers to publish LEK.

Publication bias?

Most LEK research is applied to studies focusing on resource management and we are unaware of any completely theoretical ecological studies employing LEK. This likely

partially explains the observed differences in numbers of LEK studies among journals. The most influential and longstanding journals had the fewest LEK papers and this has not substantially changed over the last 25 years. Yet there are still opportunities to publish LEK research in high impact journals. Two of the journals that most regularly published LEK papers (Conservation Biology and Ecological Applications) were identified as being in the top twenty ecological journals (Olden 2007). We suggest that LEK research should be given meaningful and equivalent review by any and all ecological and conservation journals. Selection of peer reviewers for manuscripts incorporating LEK should ensure adequate experience and sensitivity in the people chosen and journals that publish LEK might also designate a specialized LEK editor with the appropriate expertise to facilitate LEK publication.

Publication bias occurs in the literature when certain types of manuscripts are preferentially accepted or rejected and these biases have been documented in many areas of the scientific literature (Dickersin 1990). Our analysis was only able to consider the papers that were actually published in each journal and we have no information on papers that were rejected. Yet our own personal experience and conversations with other researchers indicates that there are substantial barriers to publishing LEK in conventional ecological journals, especially for studies that incorporate both social and biophysical data. This is unlikely to change until the underlying editorial policies and attendant training and skills of the editorial staff become more diverse and accepting of the value of local knowledge.

Communities as research collaborators

Since local knowledge research necessarily includes humans as research participants, a careful consideration of the socio-political and cultural implications of the entire research process is needed. Indeed, increasing numbers of communities and individuals are becoming frustrated with the inappropriate use of their knowledge by researchers, especially when there are few if any tangible benefits for participating (Nadasdy 1999; Simpson 2001a) and in at least some cases their knowledge is being stolen as they become victims of "biopiracy" (Shiva 1997). Appropriate documentation and use of LEK requires a considerable investment by scientists working collaboratively with communities, including repeat visits to discuss study design, data collection, and to synthesize and share results (Brook 2007). Our results indicate that this rarely occurs. This, in turn, raises questions about how appropriate the resulting depictions of LEK are and, indeed, leads to concerns regarding intellectual property rights and the ownership and control of the resulting data (Brush 1993; Simpson 2001b; Simpson 2004).

The use of local knowledge provides many diverse opportunities in ecological and conservation research, but it should be undertaken with support from experienced LEK researchers and only after developing a collaborative relationship with the community that are involved in or affected by the research. Although the recently published LEK studies represent important first steps in developing a process of incorporating local knowledge into ecology and conservation, most failed to obtain adequate input from the community on study design or feedback on final results. Experience-based knowledge should be treated differently from other data, and concerns regarding the ownership and control of the data are rarely raised by researchers, much less revolved with the participants (Brook and McLachlan 2005). Finally, and perhaps most significantly, the spiritual and especially the political contexts of local knowledge were very rarely included in the studies we examined. The most effective way of addressing these shortcomings is to actively involve resource-dependent communities throughout the research in order to better and more explicitly reflect their concerns and, ultimately, their true expertise (Uriarte et al. 2007).

Although there is a growing appreciation of researchers to be ever more inclusive and respectful of local people, many studies still fall short of the mark. Indeed, many communities continue to feel peripheralized by LEK research process. A recent study by ITK and NRI (2007) found that while the Inuit people of northern Canada were supportive of research, the communities were deeply concerned about how research is conducted. They were particularly disappointed with the lack of input and consultation in identifying research needs, forming research questions, and designing studies, an overall lack of local involvement in the research process, and generalization and decontextualization of local knowledge. These concerns have been raised previously by other communities throughout Canada as well (e.g. Mulvihill and Baker 2001; Simpson 2004).

LEK guidelines

In response to this obvious shortfall in effective LEK research approaches, guidelines are now being developed in Canada that facilitate working with communities respectfully and using their knowledge appropriately. The Tri-Council of federal funding agencies in Canada (Natural Sciences and Engineering Research Council of Canada, Social Sciences and Humanities Research Council of Canada, and Canadian Institutes of Health Research) has been actively developing guidelines that address this issue (CIHR, NSERC, SSHRC 1998; Martin-Hill and Soucy 2005; Canadian Institutes of Health Research 2007). A key point made by the recent CIHR document was that:

> An Aboriginal community should have an opportunity to participate in the interpretation of data and the review of conclusions drawn from the research to ensure accuracy and cultural sensitivity of interpretation. Research involving Aboriginal people is susceptible to misinterpretation or misrepresentation when information about the group is analyzed without sufficient consideration of other cultural characteristics that make the group distinct. (Canadian Institutes of Health Research 2007).

As suggested by Stevenson (1998), we need to begin thinking of LEK not so much as a commodity but as a process to be developed and nurtured. This process requires that the knowledge holders be meaningfully involved, from proposal to publication

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